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## AN IMPLANT DEVICE FOR APPLYING COMPRESSION ACROSS A FRACTURE SITE

### FIELD OF THE INVENTION

The invention relates to an implant device for applying compression across a fracture site in a bone and in particular to such an implant device which is constructed as a wire element which is used without separate pins.

### BACKGROUND AND PRIOR ART

By way of example, fractures of the olecranon (upper end of the ulna at the level of the elbow) and fractures of the patella (kneecap) are fractures that involve an articular surface. Restoration of the joint surface to anatomic alignment is the accepted method of fixation.

Both the olecranon and patella are loaded during joint flexion. The deep articular surface is loaded in longitudinal compression by the reactive forces across the articular surface; the superficial bone surface is loaded in tension by the pull of a strong muscular insertion (the triceps in the case of the olecranon, and the quadriceps tendon in the case of the patella). As a result, these bones normally have a compressive side (deep surface) and a tension side (superficial surface).

A well accepted method of fixation of both olecranon fractures and patella fractures is a technique known as figure 8 tension band wiring. Figures 1 and 2 show an example of the known technique. Referring to these figures, two stiff stainless steel pins A are driven longitudinally into bone B across the fracture site C. Instead of pins, screws can be

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utilized. A flexible wire D is passed through a drill hole E on one side of the fracture site C and the two ends of the wire are crossed over the fracture site to the opposite side. One wire is then passed under the ends F of the two pins A, and the wire twisted and tightened at G to the other end to develop tension in the wire to produce compression across the fracture site.

The tension band technique holds the tension side of the bone in apposition. Since the deep surface is under load from the articular surface, the technique results in production of compressive force across the fracture site, resulting in secure fixation, promoting early union of the fracture and early motion of the joint.

One problem with this standard figure 8 tension band wiring occurs because standard large pins A are used which protrude from the end of the bone at F at the location where a major tendon inserts. Because of this, the ends F of the pins frequently cause irritation of the soft tissues and require removal.

A minor technical problem with the standard figure 8 tension band wiring is that the passage of the wire through drill hole D and through the tendon and under the pins can be cumbersome.

#### SUMMARY OF THE INVENTION

An object of the invention is to provide an implant device which overcomes the above problems and disadvantages by avoiding the use of the stiff pins and providing a continuous length of wire to apply the compressive force across the fracture site.

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The above and further objects of the invention are achieved by an implant device which comprises a wire element having a first portion adapted to be implanted into a bone across a fracture site in the bone, and a second portion integrally formed with the first portion and extending outside the bone for passing on a superficial surface of the bone such that the first and second portions are juxtaposed with one another, and a fixation element adapted to be secured to the bone, for cooperating with the second portion of the wire element to maintain tension force in the second portion for producing compression of the bone across the fracture site.

In a particular embodiment, a tensioning device is engageable with said fixation element and with said second portion to develop said tension force.

#### BRIEF DESCRIPTION OF THE FIGURES OF THE DRAWING

Figure 1 is a side view of a conventional fixation device.

Figure 2 is a plan view, from below at the posterior side in Figure 1.

Figure 3 is a side view of the fixation device of the invention implanted in a bone.

Figure 4 is a perspective view of one embodiment of the fixation device.

Figure 4A is a perspective view of another embodiment of the fixation device.

Figure 5 is a plan view of the fixation device at the posterior side.

Figure 6 shows the device of Figure 5 with a tensioning device prior to application of tension force.

Figure 7 shows application of tension force by the tensioning device.

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Figure 8 is a side view of a modified embodiment of the fixation device in which the wires are crossed at the upper or superior surface of the bone.

Figure 9 is a top plan view of the device in Figure 8..

Figure 10 is an end view of the device in Figure 8.

Figure 11 is an elevational view of a different embodiment of the tensioning device in a relaxed state.

Figure 12 shows the tensioning device of Figure 11 in an active state in which tension is applied to the fixation device.

Figure 13 is a sectional view taken along line 13-13 in Figure 11.

Figure 14 is a sectional view taken along line 14-14 in Figure 11.

Figure 15 is a plan view illustrating a further embodiment of the invention.

Figure 15A is a plan view of a modification of the embodiment illustrated in Figure 15.

Figure 16 is a side elevational view of the embodiment illustrated in Figure 15.

Figure 17 is a top plan view showing the embodiment of Figure 15 installed in the bone.

Figure 17A is similar to Figure 17 but illustrates the modification in Figure 15A.

Figure 18 is a side elevational view showing the embodiment of Figure 15 installed in the bone.

Figure 19 is a top plan view of a further embodiment of the invention.

Figure 20 is a side elevational view of the embodiment in Figure 19.

Figure 21 is an end view as seen in the direction of arrow X in Figure 19.

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Figure 22 is a sectional view taking on line 22-22 in Figure 20.

Figure 23 is a side elevational view showing the embodiment of Figure 19 installed in the bone.

Figure 24 is a top plan view of Figure 23.

Figure 25 is a sectional view taking along line 25-25 in Figure 23.

Figure 26 is a plan view of a further embodiment according to the invention.

Figure 27 is a side elevational view of the embodiment shown in Figure 26.

Figure 28 is a plan view of a further embodiment according to the invention.

Figure 29 is a side elevational view of the embodiment illustrated in Figure 28.

Figure 30 is a plan view of a further embodiment of the invention shown installed in the bone.

Figure 31 is an elevational view of Figure 30.

Figure 32 shows a further embodiment of the invention installed in the bone.

Figure 33 is an elevational view of Figure 32.

Figure 34 shows a further embodiment installed in the bone.

Figure 35 is a plan view showing a further embodiment installed in the bone.

Figure 36 is a top plan view of another embodiment of a fixation device according to the invention.

Figure 37 is a side elevational view thereof.

Figures 38 and 39 illustrate successive stages of installation of the fixation device of Figure 36.

Figure 40 shows the installation of the fixation device in top plan view.

Figure 41 shows the installation of the fixation device in elevational view.

## DETAILED DESCRIPTION

The drawings illustrate a fracture fixation implant device 1 for applying compression across a fracture 2 in a bone B. The bone B, for example, may be the olecranon or the patella that involve an articular surface.

The implant device 1 comprises a continuous wire element 3 formed with two spaced longitudinally extending legs 4 which are adapted to be driven into the bone B across the fracture 2. The term "wire" or "wire element" is an art recognized term and covers elements having circular or rectangular cross-sections and commonly referred to as pins, wires or bars. The legs 4 form a first portion 5 of the wire element and the legs 4 extend at their ends remote from free ends 6 thereof to bend portions 7 extending outside the bone. Integrally connected to bend portions 7 is a second portion 8 extending backwardly from the bend portions 7 in juxtaposition with the legs 4 of the first portion 5. The second portion 8 includes legs 9 continuous with respective bend portions 7 and crossing one another at an intersection 10 which is located approximately at the fracture 2. The legs 9 extend to a connecting portion 11 in the form of a U-shaped bend to complete the continuity of the wire element 3. In Figure 3 the wire element 3 is illustrated in an embedded condition in the bone so that the second portion 8 extends on a lower or posterior surface 12 of the bone.

Figure 4A illustrates a modified embodiment of the wire element in which the same numerals are used to designate the same parts and primes are used for modified parts. In Figure 4A, the wire element 3' has legs 9' of the second portion 8' which do not cross one another as in Figure 4 but are spaced from one another. In other respects, the wire element 3'

is the same as wire element 3 in Figure 4.

Hereafter, the invention will be described with reference to the wire element 3 of Figure 4, but it is to be understood that the wire element 3' could also be used.

A washer 15 is secured at the posterior surface 12 of the bone by a bone screw 16. The legs 9 are loosely disposed below the washer 15. A tensioning device 20 is then installed between the washer 15 and the bend portion 11 of the wire element 3. The tensioning device 20 includes a rotatable cam 21 temporarily installed in the bone. In the position shown in Figure 6, the cam does not apply any tension to the wire element 3. When the cam is turned from the position shown in Figure 6, a force is applied to the U-shaped bend 11 which develops tension in the wire element and causes the bend portions 7 to bear tightly against the distal end of the bone and produce compression across the fracture 2. In the ninety degree position shown in Figure 7 of the cam 21, a maximum compression is developed across the fracture 2. When the proper tension has been developed in the wire element, the washer which has been loosely seated by the bone screw 16 is then fully seated by tightening the bone screw 16. Thereby, the tension in the wire element is maintained. The cam 21 which has been temporarily installed in the bone is then removed.

Figures 8-10 are similar to the embodiment of Figures 3-7 except that the second portion 8 with the legs 9 or 9' is adapted to extend on the upper or anterior surface of the bone and tensioning of the wire element takes place at the upper surface. In practice, the legs 9 or 9' can be positioned on any superficial surface of the bone.

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The installation of the implant is carried out as follows.

Two holes are drilled at the end of the bone at a spacing corresponding to the width of the implant as measured by the spacing of the legs 4 of the implant device thereof. The legs 4 of the implant device are impacted longitudinally into the drilled holes entering and aligning to the medullary canal. The fracture site is closed and the implant device is firmly seated and secured with the bone screw and washer to the bone at one end of the implant device. Compression at the fracture is achieved by turning the cam between the washer and the U-shaped bend of the implant device to effect further compression whereafter the screw is fully tightened and the washer is seated and then the cam is removed. In lieu of the cam, the tension force in the wire element can be produced by the surgeon applying pressure to the U-shaped bend portioin 11 and then tightening the bone screw 16 while the wire is under tension.

Implant devices having wire elements of different diameter are suited for different bone fractures. For example, a 0.062 inch diameter wire can be used for olecranon fractures whereas a larger diameter wire would be used for patella fractures and a smaller diameter wire element would be used for transverse lateral or medial malleolar fractures.

In accordance with a particular feature of the invention, the diameter of the wire of the continuous wire element need not be uniform along its length and it is particularly advantageous if the legs 4 of the wire element are of greater diameter than the remainder of the wire element in the legs 9 or 9' and U-shaped bend 11 of the second portion 8 or 8'. In this way, absolute reliability of the embedded legs 4 of the first portion is obtained while

flexibility of the wire element of the second portion can be obtained to achieve development of adequate tension in the wire element and resulting compression across the fracture.

Figures 11-14 show another embodiment of the tensioning device designated generally by numeral 30. The tensioning device 30 comprises lever arms 31 and 32 connected together by a hinge 33. The arms 31 and 32 have respective hand-engaging gripper ends 34 and 35 above the hinge 33 and actuator arms 36 and 37 below hinge 33. The arm 36 supports an actuating jaw 38 at its lower end and the arm 37 supports a counter-bearing jaw 39 at its lower end. The jaws 38 and 39 are slidable with respect to one another and jaw 38 can be moved from an inactive state, as shown in Figure 11 in which the wire element is not subjected to tensile stress by the tensioning device, to active state as shown in Figure 12 in which the jaw 38 has been displaced to apply tension to the wire element. The jaw 39 is connected by a strut 40 to an actuator plate 41 and the jaw 38 is connected by struts 42 to a counter-bearing plate 43. The counter-bearing plate 43 can be secured by a temporary pin 44 which is placed in a drill hole in the bone. The U-shaped bend 11 of the second portion 8 of the wire element, passes around a back surface of the actuator plate 41. When the lever arms 34 and 35 are brought together as shown in Figure 12, the actuator plate 41 is displaced away from the counter-bearing plate 43 to produce tension in the wire element. When the desired degree of tension has been achieved, the bone screw 16 is fully tightened, the pin 44 is extracted and the tensioning device is removed.

Although the prior figures have depicted an implant with two separate legs for both the first portion 5 and the second portion 8, either the first portion 5 or the second

portion 8 or both may consist of one leg or more than two legs

Referring to Figures 15 and 16, therein is shown a further embodiment of a fixation device 103 according to the invention in which the first portion consists of a single leg. The fixation device 103 has a leg 104 adapted for insertion into the bone and the leg 104 extends to a bend 107 connected to one leg 109 of the second portion 108 of the device. A U-shaped bend 111 connects leg 109 with a second leg 109 of the second portion 108. Figures 17 and 18 illustrate the installation of the fixation device 103 in bone B. As seen therein, the leg 104 is driven into the bone and extends across the fracture 102 and the second portion 108 consisting of legs 109 extends on an outer surface of the bone. The legs 109 of the second portion are secured to the bone by a bone screw 116 installed in a washer 115, following the development of tension in the device in a manner previously explained..

Figures 15A and 17A illustrate a modification of the embodiment illustrated in Figures 15 and 17. Herein, the fixation device is comprised of two parts 63 each having a leg 64 adapted to be implanted into the bone to form fixation portion 65. The leg 64 is connected by a bend 67 to second leg 69 of second portion 68 which extends backwardly and is juxtaposed with leg 64. The second legs 69 of the two parts 63 can be pulled to fix the fracture and develop tension in parts 63 and apply compression across the fracture. Washer 75 is secured to the bone by bone screw 76 to connect the second legs 69 together and maintain the tension developed in the two parts 63 via the second legs 69.

Figures 19 through 25 illustrate another embodiment of the fixation device

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according to the invention which is particularly applicable to the fixation of a fracture of the olecranon. This embodiment is distinguished from the earlier described embodiments in that the second portion 208 is non-planar but is bent in more than one plane to match the contour of the bone as shown with particularity in Figure 25. In particular, the fixation device comprises two legs 204 which are driven into the intramedullary canal across the fracture 202. The legs 204 extend to the bend portions 207 which extend out of the bone to the second portion 208 which comprises the crossed legs 209 connected together by the U-shaped bend 211. It is noted that the U-shaped bend 211 is not composed only of curved portions but includes a straight portion with end radii connecting the U-shaped bend 211 to the legs 209 of the second portion 208. When reference is made in this disclosure to the U-shaped bend, this not only includes curved portions but portions which can be straight and includes such configurations as V-shaped bends and the like. The legs 209 of the second portion 208 have a transition region 220 in which the legs are bent out of plane and pass in opposition at the sides of the bone as shown in Figure 25. The U-shaped bend 211 extends out of plane and connects the ends of the legs 209 as shown in Figures 22 and 25. The legs 204 are formed with a larger diameter than the legs 209 and there is a gradual taper in diameter between the legs at the bend portions 207. As evident from Figure 25, the U-shaped bend 211 which is curved in two planes engages the surface of the bone B and forms a stabilized engagement therewith.

Figures 26 and 27 show another embodiment of the fixation device designated 303 which is similar to the embodiment shown in Figure 4A. The same reference numerals will be used to designate the same parts. The fixation device 303 is particularly applicable for

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fractures at the distal end of the ulna which is often fractured in addition to fractures of the distal radius. In this embodiment, the diameter of the wire elements is constant throughout and the characterizing feature is that the legs 4A which are inserted into the bone (the ulna) are not linear but have a curved or bent shape to produce a resilient effect when inserted into the intramedullary canal to produce greater fixation of the bone from the interior and help prevent the device from rotating due to resilient engagement of the legs 4A within the intramedullary canal. In use, the free ends of the legs 4A of the fixation device 303 are inserted into the intramedullary canal and squeezed together so that upon further insertion the more widely spaced bend portions of the legs 4A are squeeze more tightly and secure the fixation device with resilient pressure against the inner wall of the intrameduallary canal.

Figures 28 and 29 show another embodiment 403 of the fixation device which is similar to the embodiment in Figure 4A and the embodiment in Figures 26 and 27. The fixation embodiment 403 in Figures 28 and 29 is particularly adapted to fractures of the patella. The fixation device 403 differs from that in Figure 4A in that bend portions 411 connecting the legs 4 and 9' are not in the same plane as the legs 9' so that the spacing between the opposite legs 9' is less than that between the opposite legs 4 as evident from Figure 28. Additionally, the diameter of the legs 4 is greater than the diameter of the legs 9' and the change in diameter takes place gradually through the bend portions 411. Referring to Figures 30 and 31, therein the fixation device 403 is shown implanted in the patellar bone 2 across the fracture 2 in which two washers 15 and two bone screws 16 are employed.

Figures 32 and 33 show another embodiment of the invention similar to the

embodiment in Figure 4 but modified to provide fixation for fractures of the proximal humerus, the distal humerus, the lateral humerus, the lateral malleolus and medial malleolus. The embodiment illustrated in Figures 32 and 33 and designated 504 differs from the earlier described embodiment of Figure 4 in that legs 504 of the fixation device are not straight but are formed with straight portions 504A and diverging non-symmetrical portions 504B. The implant thereby is adapted to the configuration of the particular bone and the relatively wide aspect or spacing of the bend portions 511 as shown in Figure 32. In this embodiment, two washers 15 and the bone screws 16 are utilized as in previous embodiments.

Figure 34 shows a variation of the embodiment in Figure 32 adapted for being implanted in the medial malleolus. In this embodiment instead of the legs of the implanted first portion 5 being non-parallel, the legs 604 are parallel and the legs of the second portion are bent and widen from the bend portions 611 to form diverging leg portions 608A which merge with parallel leg portions 608B.

In a modification shown in Figure 35, the legs of the first portion include diverging portions 704A which then converge to portions 704B which are joined to bend portions 711 connected to the crossing legs of the second portion of the fixation device.

Figures 36 and 37 show another embodiment of a fixation device 703 having a single straight leg 704 forming the first portion 705 of the fixation device connected by a bend portion 711 to a single leg 709 forming the second portion 708 of the fixation device. At the end of leg 709, a 90° bend is formed to define a hook 710.

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In Figure 38, the leg 704 of the fixation device is impacted into the intramedullary canal of the bone B across the fracture 2. An anchoring hole 712 is drilled in the bone B and is engaged by one arm 713 of a tensioning instrument 714. The other arm 715 engages the hook 710 at the end of leg 708. The tensioning instrument is then closed as shown in Figure 39 to close and compress the fracture. A guide hole 715 is drilled in the bone B tensioning instrument 714 is then removed and hook 710 is impacted into the guide hole 715. A bone screw 716 and washer 717 is then installed to hold end of the leg 709 in place.

The embodiment shown in Figures 36-41 differs from the previously described embodiments in that instead of fixedly securing the end of leg 708 by the washer and bone screw, the hook which is impacted into the bone serves for anchoring the leg 708 and the bone screw and washer only serve for preventing the end of the leg from coming out of the bone. In the previously described embodiments the bone screw has to be tightened with substantial force to prevent the leg under the washer from sliding on the bone.

Although the invention is disclosed with reference to particular embodiments thereof, it will become apparent to those skilled in the art that numerous modifications and variations can be made which will fall within the scope and spirit of the invention as defined by the attached claims.